

SIX-QUARK CONFIGURATIONS IN THE NN SYSTEM CORRELATED WITH EXPERIMENT

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Abstract

The nucleon-nucleon interaction at short range is analyzed in terms of six-quark configurations on a base of numerical solutions of modified RGM equations. It is shown that in low partial waves $L=0,1$ the system has a two-channel character: the NN channel and the inner six-quark state ("bag") with specific color-spin structure. Starting from this analysis it is shown that polarization observables could be a good tool for investigation of a quark structure of the deuteron.

1 Introduction

Now it is still impossible to deduce the nucleon-nucleon interaction, nucleon-meson form factors and other hadron properties directly from the QCD and we are forced to use for these purposes models inspired by QCD (effective colorless field, constituent quarks, chiral solitons, *etc.*). In our opinion the quark model approach to the intermediate energy nucleon-nucleon dynamics is more appropriate than the standard meson-exchange diagram technique, which is inefficient in this area because of a large uncertainty of meson-nucleon form factors and a basic inadequacy of the meson perturbation theory. Considering nucleons as three-quark clusters we can reduce complex problems of nucleon-nucleon and meson-nucleon dynamics to more simple ones that could be solved with well known algebraic methods of the nuclear clustering theory^{1,2,3}).

On a base of the quark-model approach it was previously shown^{4,5,6}) that in the NN system at short range (in low partial waves $L = 0, 1$) the excited six-quark configurations s^4p^2 ($L = 0$) and s^3p^3 ($L = 1$) play a key role because of their non-trivial permutation symmetry (Young schemes $[42]_X$ and $[3^2]_X$ correspondingly). The

point is that in these configurations the every color-spin (CS) state from Clebsch-Gordon series of inner production of color (C) and spin (S) Young schemes

$$[f_{CS}] = \begin{cases} [2^3]_C \circ [42]_S = [42]_{CS} + [321]_{CS} + [2^3]_{CS} + [31^3]_{CS} + [21^4]_{CS}, & S=1, \\ [2^3]_C \circ [3^2]_S = [3^2]_{CS} + [41^2]_{CS} + [2^2 1^2]_{CS} + [1^6]_{CS}, & S=0 \end{cases} \quad (1)$$

satisfies the Pauli exclusion principle in all spin-isospin channels (S,T)=(1,0), (0,1), (0,0), (1,1). So we can construct a fully antisymmetrised (over quark permutations) nucleon-nucleon wave function at short range on a base of excited configurations only. On the contrary the Pauli principle constraints ("Pauli blocking") play a crucial role for non-excited configurations s^6 ($L = 0$) and s^5p ($L = 1$). It is a consequence of a very simple permutation symmetry of configurations s^6 and s^5p (Young schemes $[6]_X$ and $[51]_X$) at which most of CS states from Eq.(1) do not satisfy the Pauli exclusion principle.

The significance of excited six-quark configurations for NN interaction at short range was confirmed by many authors (see e.g. Ref.⁷) with resonating group method (RGM) calculations at low energy $E_{lab} < 0.5 \text{ GeV}$ and by our modified RGM calculations⁶) in a large interval of energy $0 < E_{lab} < 1.5 \text{ GeV}$. However it is still impossible to correlate excited (s^4p^2 , s^3p^3) or non-excited (s^6 , s^5p) configurations with any observable effects. This is a general problem of "visualization" of quark degrees of freedom in nuclear phenomena at intermediate energy.

In this report we should like to show that in experiments with polarized deuteron beams there are a possibility to observe effects which is connected with specific spin structure of excited six-quark configurations in the deuteron. The non-excited configurations could be correlated with observed structures in the energy dependence of spin asymmetry of NN scattering cross section at intermediate energy as it was shown in works.^{8,9})

2 Modified RGM approach

As it was said above in the lowest six-quark configurations $s^6[6]_X L=0$ and $s^5p[51]_X L=1$ most of the CS states from Eq.(1) are forbidden and the excited configurations $s^4p^2[42]_X L=0$ and $s^3p^3[3^2]_X L=1$ play an important role in the NN interaction at short range. If allowed states in the configurations s^6 and s^5p (e.g. $s^6[6]_X [2^3]_{CS} LST=010$ in the 3S_1 channel) do not play a crucial role in the NN dynamics at short range we can isolate them in the NN function (in the first approximation), and the remainder would be a nodal NN wave function. It could justify a good description of the NN scattering in terms of Moscow potentials with forbidden states in low partial waves $L = 0, 1$ ^{10,11}) and show that there is a simple origin of the repulsive core in the NN system independently on the form of qq interaction and just as a consequence of the Pauli exclusion principle. To verify such picture of NN interaction at short range the sophisticated numerical RGM calculations were recently made.⁶)

The large basis of six-quark configurations was incorporated into the RGM wave function by using the two-centered shell-model basis,

$$| S_+^3(R)S_-^3(R)[f_X][f_{CS}]LST > \equiv | S_+^3S_-^3\{f\}LST >, \quad \{f\} \equiv \{[f_X], [f_{CS}]\} \quad (2)$$

where $S_{\pm}(\mathbf{R}) = \mathcal{N} \exp[-\frac{1}{2b^2} \sum_{i=1}^3 (\mathbf{r}_i \mp \frac{\mathbf{R}}{2})^2]$. The trial wave function of our modified RGM is taken in the form of an integral over the generator coordinate R and a sum over Young schemes f

$$\Psi_{NN}^{RGM}(1, 2, \dots, 6) = \sum_f \int_0^\infty \chi_f^L(R) [\mathcal{I}_{f_X}^L(R, R)]^{-\frac{1}{2}} | S_+^3(R)S_-^3(R)\{f\}LST > R dR, \quad (3)$$

$$\chi_f^L(R) = x_f^L \frac{\delta(R)}{R} + U_f^{NN} [\tilde{N}_{f_X}^L(k, R) + \cot \delta_L \tilde{J}_{f_X}^L(k, R)], \quad (4)$$

where $\tilde{N}_{f_X}^L(k, R)$ and $\tilde{J}_{f_X}^L(k, R)$ are generator coordinate analogies of spherical Bessel functions $n_L(kR)$ and $j_L(kR)$, which correspond to free asymptotics of NN scattering. In the Eq.(4) the U_f^{NN} is a unitary matrix of transformation from Young schemes $\{f\}$ to quantum numbers of the NN channel. Coefficients x_f^L and phase shifts δ_L are unknown values, which must be calculated by the solution of the RGM equations at fixed energies of the NN system $E_{NN} = k^2/m_N = k^2/3m_q$. The δ -functions in the trial functions Eq.(4) incorporate six-quark shell-model configurations $s^6[6]_X\{f\}$, $s^4p^2[42]_X\{f\}$, *etc.* to the RGM wave function Eq.(3). It is well known,¹²⁾ that two-centered configurations Eq.(2) in the limit $R \rightarrow 0$ become standard shell-model states with the same Young schemes $\{f\}$:

$$\lim_{R \rightarrow 0} [\mathcal{I}_{f_X}^L]^{-\frac{1}{2}} | S_+^3(R)S_-^3(R)\{f\}LST > = \begin{cases} | s^6[6]_X\{f\}LST >, & \text{if } [f_X] = [6], \\ | s^4p^2[42]_X\{f\}LST >, & \text{if } [f_X] = [42] \end{cases} \quad (5)$$

We reduce the RGM equations to a system of linear algebraic equations for x_f^L and $\cot \delta_L$ and the solution of the modified RGM equations has a form of a superposition of the six-quark configurations s^6 and s^4p^2 and the asymptotical RGM states in the NN channel

$$\begin{aligned} \Psi_{NN}^{RGM}(1, 2, \dots, 6)_{L=0} &= x_{[6]}^{L=0}(k) | s^6[6]_X[2^3]_{CS}LST = 010 > \\ &+ \sum_{f_{CS}} x_{[42]_X[f_{CS}]}^{L=0}(k) | s^4p^2[42]_X[f_{CS}]LST = 010 > \\ &+ \sqrt{10}A \left\{ N(1, 2, 3)N(4, 5, 6)(1 - e^{-\frac{r^2}{4\gamma^2}})[n_L(kr) + \cot \delta_L j_L(kr)] \right\}_{L=0} \end{aligned} \quad (6)$$

3 Analysis of the NN wave function at short range on a base of microscopical calculations

The model of interaction. We make use of the quark Hamiltonian

$$H_q = \sum_{i=1}^6 (m_q + \frac{p_i^2}{2m_q}) + \sum_{i>j=1}^6 (V_{ij}^{OGE} + V_{ij}^{Conf.} + V_{ij}^{II} + V_{ij}^{Ch.}), \quad (7)$$

where V_{ij}^α , $\alpha = OGE, \dots, Ch.$ are effective qq potentials of perturbative QCD interaction

$$V_{ij}^{OGE} = \alpha_s \frac{\lambda_i \lambda_j}{4} [\frac{1}{r_{ij}} - \frac{\pi}{m_q^2} (1 + \frac{2}{3} \sigma_i \sigma_j) \delta(\mathbf{r}_{ij}) - \frac{1}{4m_q^2} \frac{1}{r_{ij}^3} S_{ij}(\hat{\mathbf{r}}_{ij})], \quad (8)$$

phenomenological confinement

$$V_{ij}^{Conf.} = -\frac{\lambda_i \lambda_j}{4} (g_c r_{ij} - V_0), \quad (9)$$

and non-perturbative QCD motivated

(i) instanton-induced (II) interaction¹³)

$$V_{ij}^{II} = -y \rho_c^2 \frac{\pi}{3} (\frac{1 - \tau_i \tau_j}{4}) [1 + \frac{3}{8} \frac{\lambda_i \lambda_j}{4} (1 + 3 \sigma_i \sigma_j)] \delta(\mathbf{r}_{ij}), \quad (9)$$

where $\rho_c = 0.3 fm$ is the instanton radius and y is an adjustable parameter, and

(ii) effective interaction of quarks with π and σ mesons inspired by NJL (Nambu-Jona-Lasinio) model of spontaneous breaking chiral symmetry (SBCS),

$$H_{Ch.} = g_{\pi qq} F(Q) \bar{\psi}(\sigma + i \gamma_5 \tau \pi) \psi \quad (11)$$

where form factor $F(q)$ is of the form $F(Q) = [1 + \sum_{k=1}^n C_k \frac{Q^2 + m_k^2}{Q^2 + \Lambda_k^2}]^{\frac{1}{2}}$ that is convenient for coordinate representation of $V_{ij}^{Ch.}$. As usual $m_\sigma = 2m_q$, $m_q = \frac{1}{3}m_N$, $\alpha_{Ch.} \equiv \frac{g_{\pi qq}^2}{4\pi} \frac{m_\pi^2}{4m_q^2} = (\frac{3}{5})^2 \frac{g_{\pi NN}^2}{4\pi} \frac{m_\pi^2}{4m_N^2} = 0.0276$. Free parameters of interactions in Eq.(8) -(11), α_s , g_c , y and V_0 , were fitted to the spectrum of non-strange baryons of positive parity with two variants for πqq form factor $F(Q)$:

(a) a "hard" form factor with momentum cut off at $Q_c \approx 1.5 GeV/c$,

(b) a "soft" form factor with $Q_c \approx \frac{1}{\rho_c} \approx 0.6 GeV/c$ (in this case the form factor $F(Q)$ approximates the function $\frac{m_q(Q)}{m_q(0)}$ where $m_q(Q)$ is the momentum dependent constituent quark mass from Diakonov's theory of light quarks in the instanton vacuum¹⁴)). Without any additional fitting of parameters we obtained not so bad description of the 3S_1 phase shift of NN scattering in a large interval of energy $0 < E < 1 GeV$ (see fig. 1).

In contrast to the earlier RGM calculations in which authors considered only low energy NN scattering up to $400 MeV$ our approach was constructed to be feasible

for intermediate energy applications too (for example the baryon spectrum in table 1 covers the range at least $0.5 - 1 \text{ GeV}$ in mass).

Table 1. Two variants of quark-quark potentials

Parameters of interaction				r.m.s.		Baryon spectrum				
	α_s	g_c	V_0	y	b	N	$N_{\frac{1}{2}+}^{**}$	$\bar{N}_{\frac{1}{2}+}^{**}$	Δ	Δ^{**}
Var.		$(\frac{MeV}{fm})$	(MeV)		(fm)					
(a)	0.42	49.4	26.0	3.	0.54	939	1437	1703	1230	1863
(b)	0.44	152.6	144.6	7.	0.56	939	1449	1715	1230	1839
Exp.:						939	1440	1710	1232	1600
							± 40	± 30	± 2	± 150

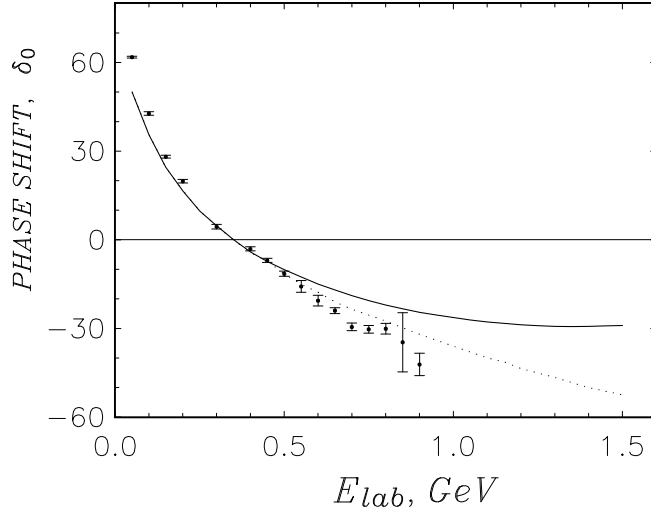


Fig. 1: 3S_1 phase shift of NN scattering. RGM calculations (var. a), solid; dynamical reconstruction on a base of Moscow potential,¹¹⁾ dots; phase analysis from Ref.¹⁵⁾

Of course it would be unreasonable to expect a quantitative description of NN scattering above $0.5 - 1 \text{ GeV}$ in any quark microscopical approach. But we can make some qualitative analysis of behavior of the system at short range on a base of microscopical calculations and it would help to develop a reasonable phenomenological potential model, which takes into account quark degrees of freedom.

NN short range behavior. The results on the NN wave function in an overlap region are shown in the fig. 2 (a) and (b). The NN component of the six-quark wave function can be obtained by projecting the RGM solution Eq.(6) into the NN channel by using the fractional parentage technique (f.p.c.)^{1,2,6)}

$$\Phi_{NN}^{L=0}(r) = \sqrt{\frac{6!}{3!3!}} \langle N(1, 2, 3)N(4, 5, 6) | \Psi_{NN}^{RGM}(1, 2, \dots, 6) \rangle \quad (12)$$

The $\Phi_{NN}(r)$ is suppressed at short distances (see fig. 2 (a)) and looks like a wave function of a standard phenomenological potential model with the repulsive core.

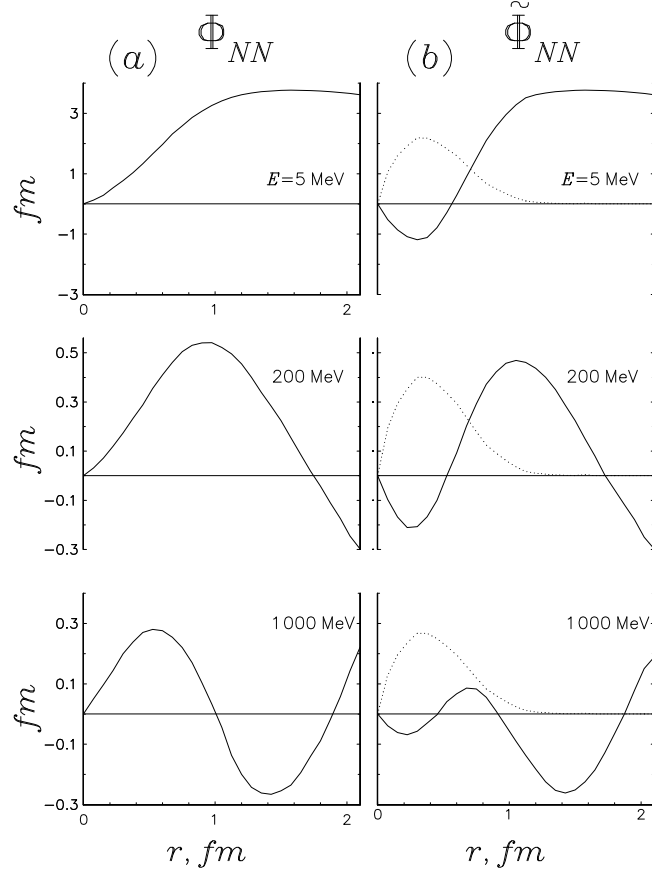


Fig. 2: Results of RGM calculations⁶⁾ at energies $E_{lab}=5, 200$ and 1000 MeV. Projections of the Ψ_{NN}^{RGM} into NN channel: (a) full function $\Phi_{NN}^{L=0}$, (b) reduced function $\tilde{\Phi}_{NN}^{L=0}$ (solid) and s^6 configuration (dots).

However, if we subtract the contribution of the configuration s^6 (the first term at the r.h.s. of Eq.(6)), we obtain a nodal wave function

$$\tilde{\Phi}_{NN}^{L=0}(r) = \sqrt{\frac{6!}{3!3!}} \langle N(1, 2, 3)N(4, 5, 6) | \left[| \Psi_{NN}^{RGM}(1, 2, \dots, 6) \rangle - x_{[6]_X}^{L=0} | s^6[6]_X[2^3]_{CS} LST = 010 \rangle \right] \rangle \quad (13)$$

with a stable position of the node at distances $r \approx b \approx 0.5-0.6$ fm in a large interval of energy $0 < E < 1$ GeV (see fig.2 (b)). The $\tilde{\Phi}_{NN}(r)$ is orthogonal to the inner $0S$ state originating from the configuration $s^6[6]_X$, which is not in essence the NN state: this configuration has approximately identical projections into any one of possible

baryon-baryon channels of given S and T ($NN, \Delta\Delta, CC, \text{etc.}$). The P -wave has also a nodal NN structure at short range (after subtraction of a contribution of the configuration s^5p from the full wave function $\Psi_{NN,L=1}^{RGM}$).

Then we can identify the function $\tilde{\Phi}_{NN}^{L=0}(r)$ as "a true NN state" in the open NN channel and the configuration s^6 as "a six-quark bag state" in the closed channel. From our microscopical quark calculations it follows (see fig. 1 and 2 (b)) that we can describe a repulsive core behavior of the NN phase shifts in S and P waves taking into account only the open NN channel with its nodal wave function at short range and using (as the first approximation to NN interaction) in this channel an attractive NN potential with the forbidden $0S$ and $1P$ states ("Moscow potential"^{10,11}). But to take into account a specific non-local character of the NN interaction at short range we have to make use of a coupled closed channel (as a second approximation) with its symmetrical six-quark wave function. Note that the closed six-quark channel is orthogonal to the NN state of the open channel. Now on a base of this consideration there is proposed a new (more adequate than standard OBEP or Moscow^{10,11}) potentials) phenomenological description of the NN interaction at short range.¹⁶⁾

4 Six-quark structure of the deuteron

The deuteron S -wave function consists also of two orthogonal components: (i) the inner part, s^6 bag (closed channel), (ii) the outer part, an orthogonal to the s^6 bag nodal NN wave function. The deuteron D wave is another NN component, connected with s^6 bag through the qq tensor forces and with S -wave NN component — through the tensor force of the pion-exchange potential. Table 2 represent the full solution for the deuteron S and D waves on the basis of 13 quark configurations.

Table 2. Quark configurations in the deuteron.

S wave:							
Conf.	s^6 [6] _X	$s^4p^2-s^52s$ [6] _X $L=0$	s^4p^2 [42] _X $L=0$				
$[f_{CS}]$	$[2^3]_{CS}$	$[2^3]_{CS}$	$[42]_{CS}$	$[321]_{CS}$	$[2^3]_{CS}$	$[31^3]_{CS}$	$[21^4]_{CS}$
Ψ_{6q}	0.155	-0.019	-0.115	0.042	0.052	-0.01	0.004
f.p.c.							
NN	$\sqrt{\frac{1}{9}}$	$\sqrt{\frac{1}{45}}$	$\sqrt{\frac{1}{25}}$	$-\sqrt{\frac{64}{2025}}$	$-\sqrt{\frac{1}{405}}$	$\sqrt{\frac{2}{405}}$	0
$\Delta\Delta$	$-\sqrt{\frac{4}{45}}$	$-\sqrt{\frac{4}{225}}$	0	0	$-\sqrt{\frac{64}{2025}}$	0	$\sqrt{\frac{4}{81}}$
N^*N	0	0	$-\sqrt{\frac{1}{50}}$	$-\sqrt{\frac{2}{2025}}$	$\sqrt{\frac{5}{162}}$	$\sqrt{\frac{1}{405}}$	0

D wave:

Conf.	$s^4p^2-s^52s$ [6] _X L=2	s^4p^2 [42] _X L=2				
[<i>fCS</i>]	[2 ³] _{CS}	[42] _{CS}	[321] _{CS}	[2 ³] _{CS}	[31 ³] _{CS}	[21 ⁴] _{CS}
Ψ _{6q}	0.007	0.045	-0.023	-0.011	0.009	-0.002
f.p.c.						
NN	$\sqrt{\frac{1}{45}}$	$\sqrt{\frac{1}{25}}$	$-\sqrt{\frac{64}{2025}}$	$-\sqrt{\frac{1}{405}}$	$\sqrt{\frac{2}{405}}$	0
ΔΔ	$-\sqrt{\frac{4}{225}}$	0	0	$-\sqrt{\frac{64}{2025}}$	0	$\sqrt{\frac{4}{81}}$
N*N	0	0	0	0	0	0

The solution differs from standard *NN* models of the deuteron in baryon-baryon (BB) and partial wave composition and has a non-trivial spin structure. This is essential for deuteron break-up reactions and we expect that new spin structure of the deuteron wave function could be observed in experiments with polarized deuteron beams.

New features of the deuteron wave function.

1) **Non-nucleon components.** Calculation of the overlap integral

$$\Phi_{B_1B_2}(r) = \sqrt{\frac{6!}{3!3!}} < B_1(123) | < B_2(456) | \Psi_{6q}(12...6) > \quad (14)$$

by means of f.p.c. technique^{1,6)} results the following spectroscopic factors for ΔΔ, N*N,...etc. components in the deuteron: $S_{\Delta\Delta} = \int | \Phi_{\Delta\Delta}(r) |^2 d^3r = 0.02$, $S_{N^*N} = \int | \Phi_{N^*N}(r) |^2 d^3r = 0.006$, ...etc. A momentum distribution of these components $\bar{\Phi}_{B_1B_2}(\mathbf{k}) = \frac{1}{(2\pi)^3} \int \Phi_{B_1B_2}(\mathbf{r}) e^{i\mathbf{k}\mathbf{r}} d\mathbf{r}$ ³ could be observed in deuteron break-up reactions as momentum distribution of the baryon-spectator.

2) **Partial wave structure. P-wave components.** In the six-quark deuteron the nucleon-spectator can originate not only from *NN* component but also from *N*N* component in which *N** is the negative parity resonance $N_{\frac{1}{2}}^*(1535)$ and the nucleon is in a P-wave state.^{6,17,19)} In the six-quark deuteron there are two different P- (*N*N*) states:

a) $^1P_1^*$ state $v_0(r)$ (with S=0) in the configuration $s^4p^2[51]_X[2^21^2]_{CS}LST=100$; by our results its probability is very small, $< 10^{-5}$, and this configuration has a zero projection into *NN* channel;

b) $^3P_1^*$ state $v_1(r)$ (with S=1) in the configuration $s^4p^2[42]_X[42]_{CS}LST=010$ with a probability of $\approx 0.5\%$

In the deuteron break-up reaction the outgoing nucleon at fixed angle θ "remembers" a partial wave and spin structure of the deuteron (if the initial deuteron is polarized). Fourier transform of the wave functions of *S*- and *D*- waves in the deuteron ($u(k)$ and $w(k)$) and *P*-wave functions ($v_0(k)$ and $v_1(k)$) are used in relativistic impulse approximation (RIA)¹⁸⁾ to define the differential cross section (see details in

Ref.^{18,17,19}))

$$E_q \frac{d^3\sigma}{dq^3} = \frac{1}{2} C_d \sigma_{NA} \frac{1}{1-x} \sqrt{\frac{m_N^2}{4x(1-x)}} \left[u^2(k) + w^2(k) + C_{off} (v_1^2(k) + v_0^2(k)) \right] \quad (15)$$

the T_{20} analyzing power

$$T_{20}(0^\circ) = \frac{1}{\sqrt{2}} \frac{2\sqrt{2}u(k)w(k) - w^2(k) + C_{off} (v_1^2(k) - 2v_0^2(k))}{u^2(k) + w^2(k) + C_{off} (v_1^2(k) + v_0^2(k))} \quad (16)$$

and the coefficient of polarization transferred

$$\kappa_0(0^\circ) = \frac{u^2(k) - w^2(k) - C_{off} \frac{3}{\sqrt{2}} v_1(k)v_0(k)}{u^2(k) + w^2(k) + C_{off} (v_1^2(k) + v_0^2(k))} \quad (17)$$

in the inclusive reaction of the deuteron break-up on nuclei at intermediate energy. Here C_{off} is a unknown coefficient $0 \leq C_{off} \leq 1$ that takes into account off-shell effects in the N^*N channel. We choose an extreme variant of P-wave structure of the deuteron with $v_0(k) = v_1(k)$ (microscopic calculations give us $v_0 \approx 0$, but these calculations are not adequate to the problem in the case of configuration $s^4p^2[51]_X L=1$, which has a minimal coupling with NN channel)

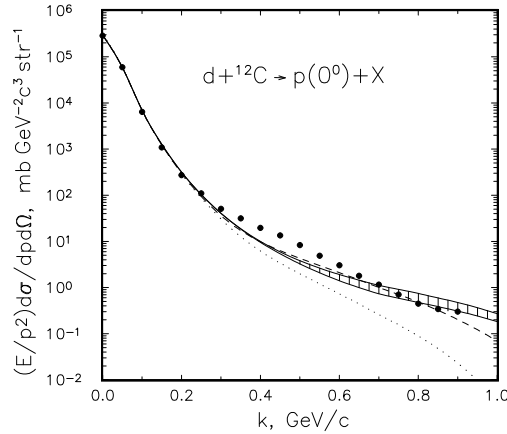


Fig. 3: Inclusive cross section of the deuteron break-up at the Dubna energy 8.9 GeV .²⁰) Calculations: six-quarks RGM without P -wave contribution (lower solid) and with P wave (upper solid), $v_0 = v_1$; Paris potential (dashed); Bonn potential (dots). Stripes show the region in which C_{off} in Eq. (16) varies from 0 to 1.

In the figures 3, 4 and 5 there is shown the observables of Eq. (15)-(17), calculated with our deuteron wave functions u , w , v_0 and v_1 (solid curves).

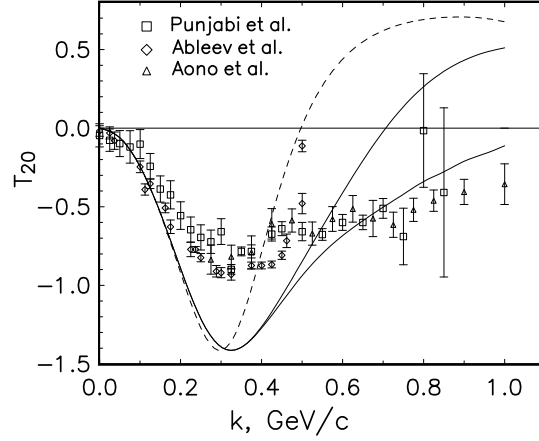


Fig. 4: The T_{20} data.^{21,22,23}) Calculations: six-quarks RGM without P -wave contribution (upper solid) and with P wave (lower solid), $v_0 = v_1$; Paris potential (dashed).

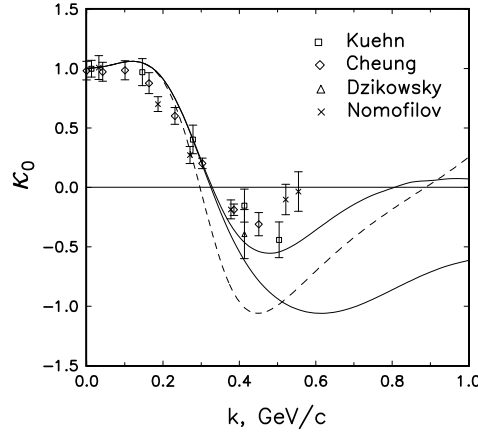


Fig. 5: Polarization transferred data.^{24,25,26,27}) Calculations: six-quarks RGM without P -wave contribution (lower solid) and with P wave (upper solid), $v_0 = v_1$; Paris potential (dashed).

Note that in the RIA a momentum $\mathbf{q} = \{q_{\parallel}, \mathbf{q}_{\perp}\}$ of the proton-spectator in the deuteron rest frame is correlated with light-front (l.f.) variables x , $\mathbf{k}_{\perp} = \mathbf{q}_{\perp}$ (or l.f. momentum $\mathbf{k} = \{k_{\parallel}, \mathbf{k}_{\perp}\}$) through the equation¹⁸⁾

$$x = \frac{\sqrt{m_N^2 + \mathbf{q}^2} + q_{\parallel}}{2m_N} = \frac{\sqrt{m_N^2 + \mathbf{k}^2} + k_{\parallel}}{2\sqrt{m_N^2 + \mathbf{k}^2}} \quad (18)$$

5 Conclusion and outlook

The NN interaction at short range (in S and P waves) is significantly non-local but this non-locality can be effectively described with the orthogonality condition to the most symmetrical (in X -space) configurations, $s^6[6]_X L = 0$ and $s^5p[51]_X L = 1$. These configurations are not in essence NN states and they have a specific color-spin structure. So some non-trivial effects could be observed in polarization experiments on the deuteron (or in NN scattering) at intermediate energies. We have above demonstrated that polarization data are sensitive to the inner quark structure of the NN system.

This approach would be useful for example in description of "structures" observed in transverse or longitudinal spin asymmetry of the NN cross-section at intermediate energies $\Delta\sigma_T = \sigma(\downarrow\uparrow) - \sigma(\uparrow\uparrow)$, $\Delta\sigma_L = \sigma(\rightharpoonup) - \sigma(\leftrightharpoonup)$ and could be considered as a development of the well known models.^{8,9)}

One can suppose that the quark Hamiltonian (16) gives an adequate description of the closed six-quark channel and the interaction that couples it to the open NN channel, but we expect that parameters of qq interaction in the six-quark system are not exactly identical with one of the three-quark system and an investigation of this problem on a base of a quantitative model of NN interaction would be very interesting.

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